No. 712,713. Patented Nov. 4, 1902.

C. A. PARSONS.

PROPULSION OF STEAM VESSELS.

(Application filed Jan. 28, 1901.)

(No Model.) 4 Sheets—Sheet 1.

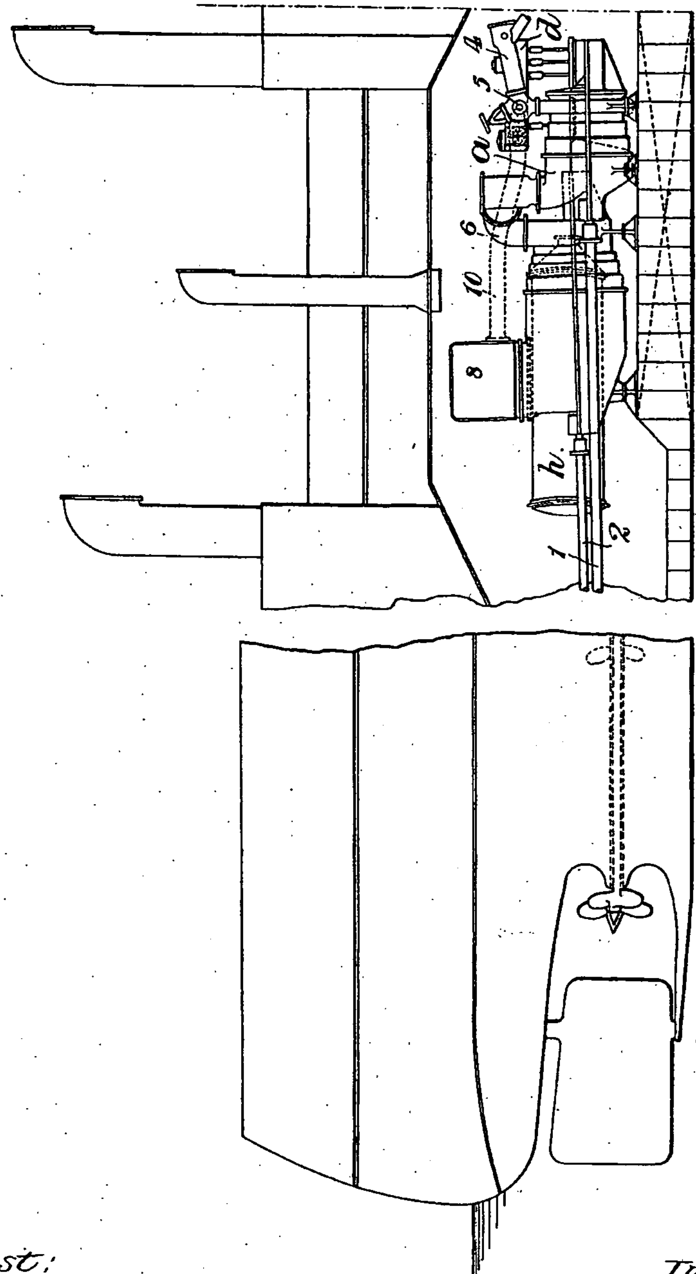

Fig. 1.

Attest:
[signature]
Edw. L. Reed

Inventor.
Charles A. Parsons.
by Ellis Spear
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 712,713.

Patented Nov. 4, 1902.

C. A. PARSONS.

PROPULSION OF STEAM VESSELS.

(Application filed Jan. 28, 1901.)

(No Model.)

4 Sheets—Sheet 2.

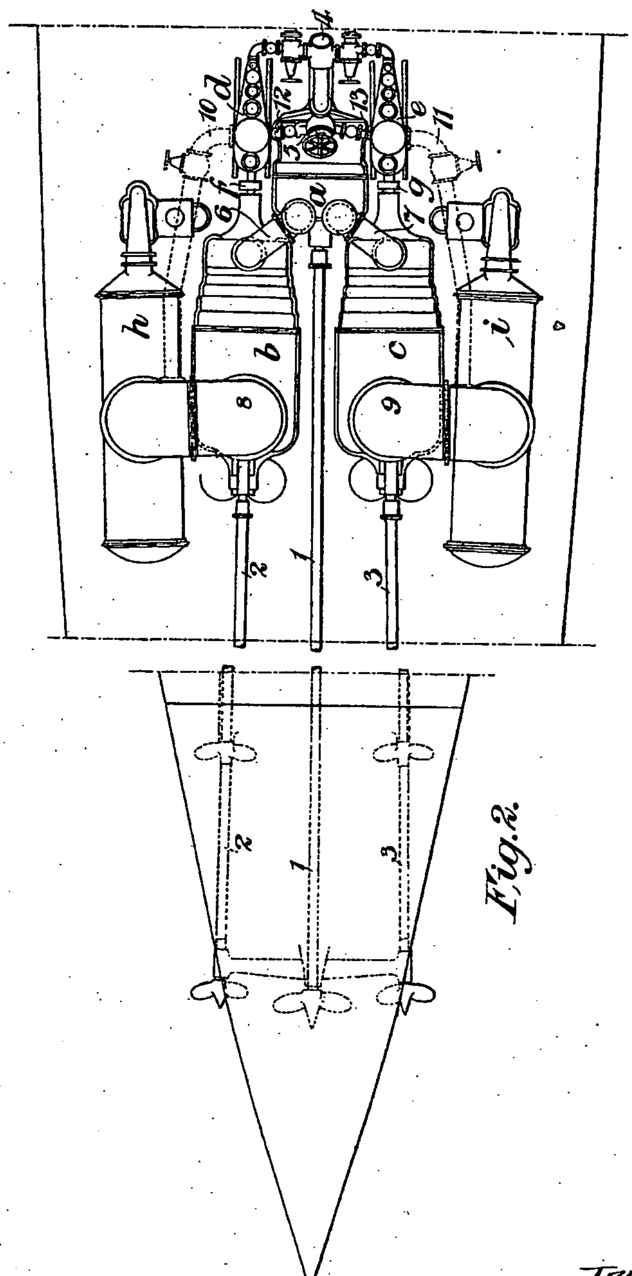

Fig. 2.

Attest:
C. S. Middleton
Edw. L. Reed

Inventor.
Charles A. Parsons.
by Ellis Spear
Att'y

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 712,713.

Patented Nov. 4, 1902.

C. A. PARSONS.

PROPULSION OF STEAM VESSELS.

(Application filed Jan. 28, 1901.)

(No Model.)

4 Sheets—Sheet 3.

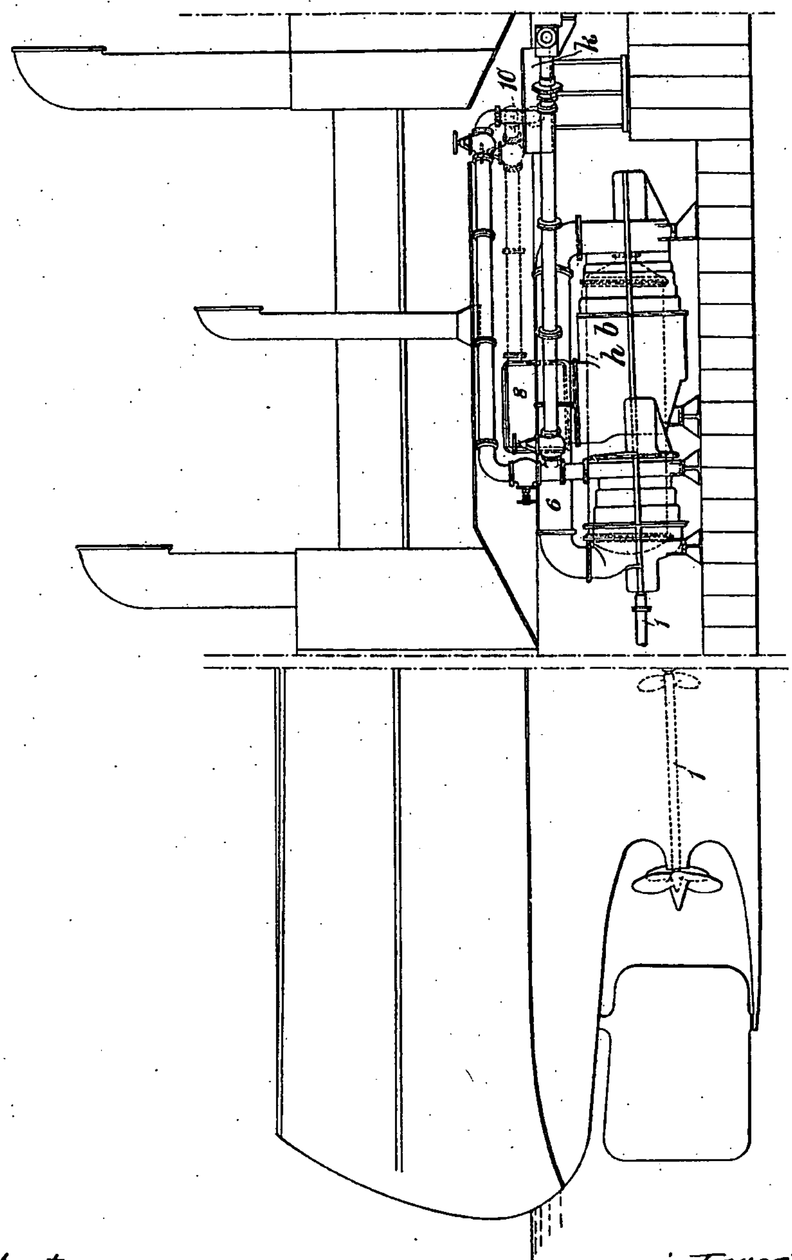

Fig. 3.

Attest:
C. A. Middleton
Edw. L. Reed

Inventor.
Charles A. Parsons.
by Ellis Spear
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 712,713. Patented Nov. 4, 1902.

C. A. PARSONS.

PROPULSION OF STEAM VESSELS.

(Application filed Jan. 28, 1901.)

(No Model.) 4 Sheets—Sheet 4.

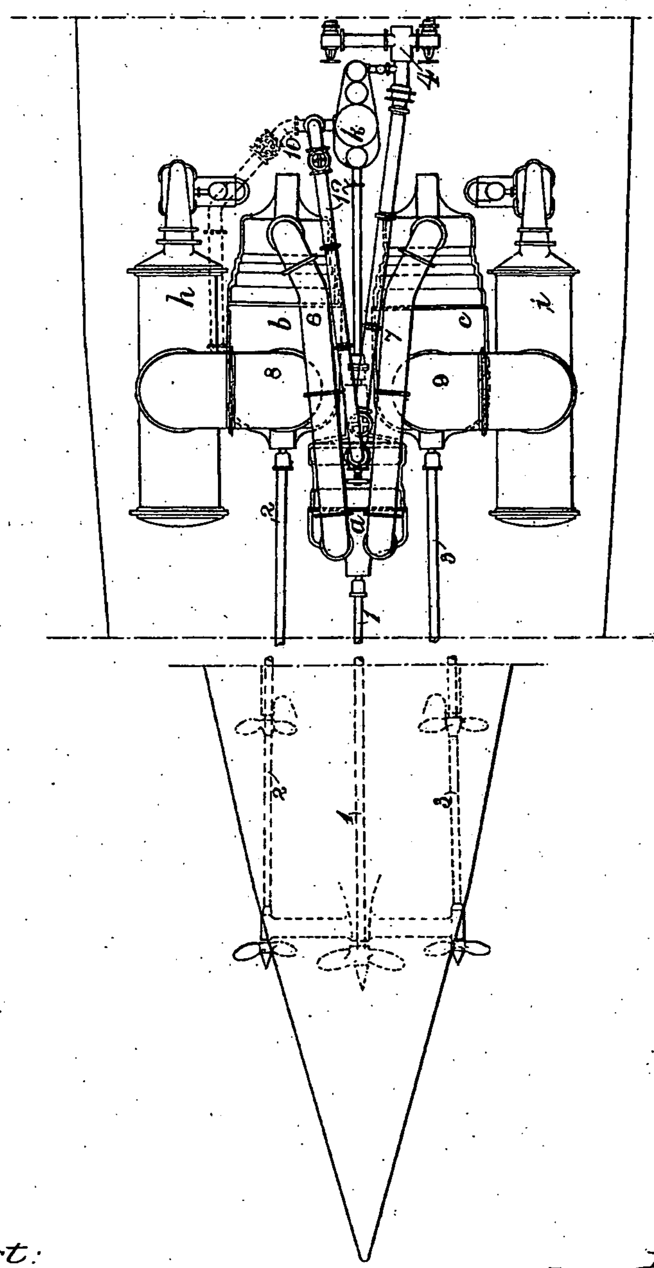

Fig. 4.

Attest:
C S Middleton
Edw. L. Reed

Inventor.
Charles A. Parsons.
by Ellis Spear
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

CHARLES ALGERNON PARSONS, OF NEWCASTLE-UPON-TYNE, ENGLAND.

PROPULSION OF STEAM VESSELS.

SPECIFICATION forming part of Letters Patent No. 712,713, dated November 4, 1902.

Application filed January 28, 1901. Serial No. 45,163. (No model.)

To all whom it may concern:

Be it known that I, CHARLES ALGERNON PARSONS, a subject of the King of Great Britain and Ireland, residing at Heaton Works, Newcastle-upon-Tyne, in the county of Northumberland, England, have invented certain new and useful Improvements in the Propulsion of Steam Vessels, (for which I have made application for patent in Great Britain, No. 16,551, dated September 17, 1900,) of which the following is a specification.

My invention relates to the application of the system of combining reciprocating engines with steam-turbines for the purpose of gaining increased economy in steam consumption.

My present invention has for its object to enable the highest degree of economy of steam consumption to be attained, both at cruising and at fast speeds; and this involves the use of highly-developed condensing-turbines having a range of expansion of from fifty to one hundred and fifty fold when working at full power.

I have experimented with turbines to determine the horse-power necessary to rotate the turbine with no steam passing through it and with various pressures, from atmosphere down to an absolute pressure of one pound per square inch in the turbine-case, and also at various speeds of revolution. I have found that taking my condensing type of turbine designed for high ratios of expansion and high steam efficiency under normal conditions of working when the steam-turbine is driven idly up to one-half its normal speed of working in a good vacuum the power required to rotate it is only about one per cent. of the normal full power output of the turbine and varies approximately as the cube of the speed of rotation.

I am well aware that many attempts have been made to place two reciprocating engines of greatly different size and power to rotate the same screw-shaft; but in consequence of the great frictional resistance to rotation of a reciprocating engine, commonly called the "idle" friction, it has been found necessary to place the smaller engine abaft the larger one and when cruising speeds are required to entirely disconnect the larger engine from the screw-shaft, which is then driven by the smaller engine only. When higher speeds are required, the larger engine is coupled up, and the larger alone, or both engines combined, drives the screw-shaft. The difficulty of coupling and uncoupling the nearly full horse-power of the vessel has been such as to render this arrangement unsatisfactory in use as also the added difficulty of transmitting the full power through the small engine-shaft. Further, owing to the high value of the idle friction such an arrangement does not give the increased economy which was aimed at and which is attained by my present invention.

In my invention, as above stated, it has been found that the frictional resistance or idle friction required to rotate the main turbine in the vacuum is so small that the turbine can be left permanently coupled to the screw-shaft to which the reciprocating engine is coupled. Further, the power transmitted by the reciprocating engine is comparatively so small that a suitable coupling, which can be easily thrown into and out of gear, can be satisfactorily used—such, for example, as a friction-coupling operated by hydraulic power. In the case of high-speed vessels where the speed of rotation of the turbines at full speed is too high for the reciprocating engine to work satisfactorily I use a detachable coupling, which can be easily thrown out of gear; but in cases where the full speed of the turbine is not too high for the reciprocating engine the latter may, if desired, be left permanently coupled.

The first part of my invention therefore consists in propelling a steam vessel by means of one or more propeller-shafts driven by a combination of one or more highly-efficient multiple-expansion reciprocating engines adapted to give the power required for cruising speeds, with one or more condensing-turbines having a high range of expansion operating on one or more of the said shafts and adapted to develop the whole or the greater part of the power required for the fast speeds, so that the highest economy of steam consumption is attained both for cruising and fast speeds, the main turbine being run in the condenser-vacuum when the reciprocating en-

gine is alone propelling the vessel. The reciprocating engine may be coupled so that it can be disconnected, if desired.

I have further found by experiment that when a turbine of the condensing type is driven by external power in a good vacuum and when small quantities of steam are admitted at the inlet and flow through the turbine to the condenser the power required to rotate the turbine falls approximately as the amount of steam admitted up to the no-load amount for that speed and that when the quantity has increased up to that amount the turbine rotates itself at the given speed without any external power and for larger, but still relatively small amounts, gives out power on the shaft.

The second part of my invention therefore relates to the combined steam-turbines and reciprocating engines dealt with above, and consists in passing the steam from the cruising-speed reciprocating engines through the main steam-turbine on its way to the condenser, thereby not only reducing the resistance to rotation of the said main turbine, but also in almost all cases adding considerably to the power developed, and thus economizing the steam required for propulsion at cruising speeds. The steam so admitted, however, may not in some cases be sufficient to directly apply power to the shaft, but may simply act to reduce the resistance to propulsion of the vessel.

My invention also comprises the complete combination of steam-turbine and reciprocating engine with steam-pipes connecting the exhaust of the reciprocating engine with the main steam-turbine inlet and then with the condenser, instead of each delivering into the condenser direct.

In applying my invention to war vessels, where economy of steam at cruising speeds and also at fast speeds is of great importance, I prefer to connect the exhaust or exhausts of the reciprocating engine or engines into the main turbines, preferably at their main steam-inlet. In this arrangement when cruising speed is required the steam may be expanded from full boiler-pressure, the first stage being in the ordinary reciprocating engine of the compound or triple expansion type and then through the main steam-turbine right down to the condenser-vacuum, the result being a very high degree of steam efficiency. When the high speeds have to be attained, the steam is admitted direct to the main turbine and passes thence to the condenser. The reciprocating engines and steam-turbines may drive the same or different shafts, and the pistons and cranks of the reciprocating engine or engines may operate on one or more of the screw-shafts.

Referring now to the accompanying four sheets of drawings, which illustrate, by way of example, two modifications of combined turbine and reciprocating engines adapted to propel a war vessel economically, both at cruising and at full speeds, by means of three propeller-shafts, Figure 1 shows in elevation, and Fig. 2 in plan, one combination and arrangement of turbines and reciprocating engines. Fig. 3 shows in elevation, and Fig. 4 in plan, another combination and arrangement. The elevations are partly in section along the longitudinal midship-section of the vessel.

In Figs. 1 and 2 this invention is shown applied to a war vessel of two thousand tons displacement, ten thousand indicated horse-power, and twenty-two knots speed. The high-pressure turbine *a* is placed alone on the central shaft 1 and exhausts into the two low-pressure turbines *b* and *c* on each side, mounted, respectively, on the side shafts 2 and 3. On the ends of each of these shafts I couple multiple-expansion reciprocating engines *d* and *e* by means of suitable hydraulic or other couplings *f* and *g*, where the speed of the turbine set at full load is higher than that of the reciprocating engines. Where these speeds are the same, however, the shafts may be rigidly coupled. At full speed the powers developed in the three turbines are preferably approximately equal, and the speed of the outside shafts 2 and 3 is seven hundred, while that of the center shaft is five hundred, revolutions per minute. The shafts 2 and 3 each carry two propellers, while the center shaft carries only one. At cruising speed, however—say twelve knots per hour—with a boiler-pressure of two hundred and twenty-five pounds per square inch, I find that I can obtain in the reciprocating engines an expansion of about fifteen-fold, while in the turbines running at the speed of the reciprocating engines I attain another fifteen-fold expansion down to the condenser-pressure of about one pound absolute. Under these conditions the reciprocating engines develop about sixty per cent. of the power required, while the turbines give the remaining forty per cent. I utilize a combination of this character to the best advantage for fast speeds by simply uncoupling the reciprocating engines and admitting the boiler-steam by way of pipe 4 and valve 5 direct into the high-pressure turbine *a* on shaft 1. This then exhausts into the two turbines *b* and *c* by way of pipes 6 and 7 and from these into the condensers *h* and *i* by pipes 8 and 9. The turbines *a*, *b*, and *c* form a set which are capable of dealing with steam at full boiler-pressure and effecting the required manifold expansion, so that economical working is obtained at full load. Economical propulsion at cruising speeds is obtained by coupling up the reciprocating engines *d* and *e* by their hydraulic or other couplings *f* and *g* to their respective shafts. The reciprocating engines in this case develop their full economical power at a speed of rotation of about three hundred revolutions per minute—*i. e.*,

less than half the full-load speed of the turbines b and c and well within the ordinary working speeds of such engines for long voyages. The aggregate power of these reciprocating engines and turbines is such that they propel the vessel efficiently at cruising speeds—say about twelve knots—and in the case given this may be about one thousand indicated horse-power, of which the reciprocating engines will produce, say, about six hundred and the turbines four hundred. In one way of working the turbines a, b, and c are all simply run in the condenser-vacuum, and the engines d and e exhaust in that case by way of pipes 10 and 11 direct to the condensers h and i, respectively. The highest economy is obtained while cruising by passing the exhaust-steam from the reciprocating engines d and e by way of pipes 12 and 13 to the turbine a and thence by way of the pipes 6 and 7 through turbines b and c to the condensers h and i. It will be seen that while cruising thus the central shaft 1 is caused to rotate by the motion of the vessel through the water acting on its propeller, and this to some slight extent causes added resistance of the vessel to propulsion. By admitting the exhaust-steam from the reciprocating engines to the turbine a I not only cancel this added resistance either partially or wholly, but in most cases add a very large fraction to the power available for propelling the vessel.

It will be obvious that in my new system of propulsion when running at cruising speeds the exhaust-steam from the reciprocating engines is utilized not only in reducing the idle friction of the turbines and shafts, but generally and in almost all cases and circumstances to positively increase the torque by a very large amount, although the most economical turbine speed is not attained.

In cruising the steam at full boiler-pressure is admitted to the reciprocating engines and is preferably expanded by them to somewhat above atmospheric pressure. It then enters the high-pressure turbine a, and thence passes through the two low-pressure turbines b and c on its passage to the condensers. The vacuum in the condensers under these conditions at cruising speeds is abnormally high, and ratios of expansion of from two to three hundred fold are practically attainable.

In Figs. 3 and 4 a modified arrangement of combined turbines and reciprocating engine is shown suited for a vessel of similar power and speed. Here only one reciprocating engine k is provided. It is placed on the central shaft 1. Its power should be about equal to the combined power of the reciprocating engines d and e in the first case, and it may be run at a slower speed than the two reciprocating engines d and e—say at two hundred and thirty revolutions per minute. In this case at cruising speeds the turbines b and c are rotated by the motion of the vessel through the water, and the consequent resistance is nullified, as before, either by opening the turbines b and c to the condenser-vacuum or more economically by the admission of the exhaust-steam from the reciprocating engine through the turbine sets on the way to the condenser. This invention enables very slow speeds also to be obtained with much greater economy than is possible with existing engines. The main air-pumps in such plants are preferably worked in the usual way by worm-gearing from the main turbine-shafts.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. A system of engines for propelling steam vessels comprising, a reciprocating engine adapted to propel the vessel at cruising speeds, a turbine engine adapted to alone propel the vessel at full speed, shafting to which the engines are connected, and condenser means to produce condenser-vacuum in which the turbine runs idly when the reciprocating engine is alone employed for propelling the vessel at cruising speeds, substantially as described.

2. A system of engines for propelling steam vessels comprising, a reciprocating engine adapted to propel the vessel at cruising speeds, a turbine engine adapted to alone propel the vessel at full speed, shafting to which the turbine is permanently connected, and a condenser for producing a condenser-vacuum in which the turbine runs idly when the vessel is being propelled at cruising speed by the reciprocating engine alone, substantially as described.

3. In combination, a reciprocating engine, a low-pressure turbine, a propeller-shaft driven by the said turbine, a high-pressure turbine, a propeller-shaft driven by the high-pressure turbine, an exhaust-steam-supply connection from the reciprocating engine to the high-pressure turbine, and an exhaust-steam-supply connection from the high-pressure turbine to the low-pressure turbine, substantially as described.

4. In combination, a reciprocating engine, a high-pressure turbine connected with the exhaust thereof and having a shaft, a direct steam connection leading to the high-pressure turbine, a low-pressure turbine, a shaft for said low-pressure turbine, a steam-supply pipe from the high-pressure turbine to the low-pressure turbine and detachable coupling means by which the reciprocating engine may be thrown out of connection, substantially as described.

5. A combined set of reciprocating engines and turbines adapted to propel a vessel economically at both fast and cruising speeds, and consisting of a high-pressure turbine driving a central shaft, two low-pressure turbines, coupled in parallel, each driving one of two outer shafts; these shafts each having detachably coupled to it a multiple-expansion steam-engine for the same or lower speed.

6. A combined set of turbines and reciprocating engine adapted to propel a vessel eco-

nomically at both fast and cruising speeds and consisting of a high-pressure turbine driving a central shaft and two low-pressure turbines coupled in parallel, each driving one of two outer shafts, said central shaft having detachably coupled to it a multiple-expansion steam-engine for the same or lower speed.

7. A set of turbines and reciprocating engines for propelling a vessel consisting in a high-pressure turbine, a central shaft driven thereby, two low-pressure turbines coupled in parallel, the two outer shafts driven by said low-pressure turbines and a reciprocating engine connected with the shafting, substantially as described.

In witness whereof I have hereunto set my hand in presence of two witnesses.

CHARLES ALGERNON PARSONS.

Witnesses:

HENRY GRAHAM DAHYM,

WILLIAM DAGGETT.